# Lez 0 - Intro

Social media platforms: persuasives and ubiquitous (information processing fully integrated within everyday activities…). We use devices that not only collect data generated on purpose, but also other useful data that can provide useful information (steps, heartrate, locations data with smartwatch…).

Data: information with context. We collect a lot of data to make decisions based on information acquired. We have a lot of data, sometimes more than we really need: challenge to have systems working on data when they get published on the internet. With the pandemic, social media have had a huge growth on the number of users; and more users means also more information.

The types of data can be: entities (books, records, tv series, characters, restaurants…), events (launch of products, events, concerts…), news (politics, entertainment, culture…), relationships (between entities, events, news…). Information is transformed in knowledge, used to make informed decisions.

We want to extract relevant (info that satisfies the user needs), valid, new, potentially useful information. SMA can be used with different aims: better life quality, improve brand reputation, forecasting the performance of financial markets… So, the main goal of this course is to know how to extract significant insights from the huge volume of mostly unstructured data using social media analyticsmethods and tools. The main concepts behind social media management are: access to data, pre-processing of data, representation of data and finally analysis.

# Internet and web technologies

Internet: global system of interconnected computer networks that use the Transmission Control Protocol/Internet Protocol (TCP/IP) protocol suite to connect devices around the world (network of networks). Connection of physical devises, via multiple options (wifi, cable…). Internet of things: concept of multiple devices (mainly sensors, such as lights, smartwatch, demotics…) can be connected daily. LAN (local area network) is a group of devices connected to the same network. The set of all the interconnected networks is called Internet. If we think of the internet as a network, nodes are the devices and the edges are the connections among these devices.

We need to establish some communication rules to help the devices communicate with each other 🡪 these are called **protocols**. This set of rules (called TCP/IP, transfer control protocol) allow different devices to communicate with each other. The IP address is the unique identification of a device on the internet/network, and this IP can be auto assigned or fixed by the user. At every moment each device connected to the network have different IP addresses, to recognize with each other.

The WWW, World Wide Web, is one of the biggest service on the Internet. The concept is due to Tim Berners-Lee, who elaborated a project to share documents inside the CERN where they used to work. The Internet is a connection of devices, the web is a connection of documents (as documents, images, videos, webpages in the form of html pages). The idea was to represent data with hypertext and share these with some basic communication rules (different from the TCP/IP rules). In the internet we identify only physical devices uniquely, in the WWW we use URI (Uniform Resource Identifier) to identify a generic resource; some example are URL (Uniform Resource Locator), a document, an image, a file, an email address... Also the web can identify as a network, with web pages as the nodes (with other multimedia contents) and the URLs as the edges. The main concepts behind the Web are hypertexts and hyperlinks.

**Structured data** (relational model, we use a DBMS) 🡪 tables/datasets. **Unstructured data** (we need Information Retrieval model to get data) 🡪 data without a scheme, like a text. **Semi-structured data** (semantic separated from the content) 🡪 some structure (markers/tags) that identify the meaning of the content, not as schematic as a table.

Web pages are written with semi-structured language (markup languages), which is HTML (**HyperText Markup Language**). (different from a programming language!!! It simply defines the structure of the content). With HTML we can also connect pages among them. An HTML file is fixed (syntax-wise, with tags already defined).

Other semi-structured data formats are: **XML** (Extensible Markup Language: is a markup language, designed to store and transport data, and to be self-descriptive) and **JSON** (JavaScript Object Notation: is a syntax for storing and exchanging data). The basic unit of XML are elements (specific block of text within a document, marked with tags); it has an hierarchical structure, like a document tree. To give some rules to XML we can do a Document Type Definition (DTD; define structure of each element and its attributes, with also some mechanism to simplify document management), or an XML schema (can do the same things as a DTD, but can define the same rules and behaviors inside the code).

JSON is similar to XML, with its own rules, but it uses a different syntax (different tags); it is constitute of pair of name/value, all written inside {}. The main differences between XML and JSON are: JSON is shorter, quicker to write and read, can use arrays and hasn’t the end tag. Both are self-describing, hierarchical and can be parsed and used by lots of programming languages. Many DBMS use JSON to store data, most from NoSQL (like MongoDB). Some other use XML to store data, such as MySQL, Oracle…

HTTP (HyperText Transfer Protocol) protocol to transfer data on the Web; it is a protocol that works with a Client/Server architecture: the client (browser) execute a request message, the server (machine where the Website resides) returns the response message. In peer2peer (p2p) network, resources are shared among peers with no central coordination by a server.

Classification between:  
- Static Web: built using HTML, stored on servers, useful for sites that never or rarely needs update.   
- Dynamic Web: they are constructed dynamically either on server side (requests like on Amazon) or on client side (like when moving the mouse on some part of the page; usually written in JavaScript); written in scripting languages and inserted within the HTML pages, processed when the user requests them.

**Web 1.0**: when users couldn’t interact with the pages, they were static and could only be read.   
**Web 2.0**: first used in 1999, no technical improvements, but changes in Web pages designs and usage (bi-directional communication, not only sites-users, but also users-users).

**Web 3.0**: semantic web technologies, with great computer capacity, growing usage of AI and new algorithms aimed at new 3D environments. Semantic related to the algorithm to explain more about the knowledge acquired on the web. To build this semantic web (term coined by Tim Berners-Lee), we need to build an environment with documents associated with information and data that specify the semantic context in a format suitable for automatic processing, querying and interpretation. Assertions are used to give information, and they are formed by subjects (Marco), predicates (works in) and values (Milan); the RDF (Resource Description Framework) is a tool useful to encode, exchange and reuse structure metadata with the aim of interpretability.

**Web 4.0**: still an unstable definition, but the direction where we are going; it should be characterized by augmented reality (all the network around us, Metaverse, domotics…), digital alter ego (we will have an alter ego online with all our information, useful to both us and the others in order to gain information), new interfaces (like home automation) and pervasive information (the society we know now may change very fast thanks to the capabilities of Web 4.0).

Social Web: set of social relationships that connect people through the WWW. Not only social networks, but also education, shopping… The aim to this course. The Social Web was born to facilitate strong relationships (friendship, love, family), share interests…

There is a distinction between data found, collected and analyzed online:  
- virtual data: collected with conventional methods (surveys, interviews…) asking participants; they are also called “provoked data” because they answer precise questions made by the researcher.   
- digitized data: material present on the network but also in other formats (e-books, online newspapers, tv recordings, music, photos…); it is an immaterial archive of potential “analogical” data.   
- digital data: traces left by a user online (web pages visited, searches, interactions on social media…); these are generated spontaneously by the individual, they don’t answer a question by a researcher; the goal of this course.

# Social Media

Social Media: they are interactive Web 2.0 applications, with content (data of all kind, like posts, videos, photos and so on) generated by users, that helps the development of online social networks. They are interacted computer-mediated technologies aimed at the creation and sharing of information via virtual communities. You are provided with a service-specific profile depending on the purpose of your activities on the social media. Social presence: acoustic, visual and physical contact that can be achieved with other users; different intimacy between users for each social media, it depends on the level on mediated communication and on the level of synchronous communication. Media richness: social media to reduce uncertainty (as lack of information); media richness as the quantity and quality of information the social media possesses.

Self-presentation: users are going to generate data on a social media in order to be part of a social community, to build a “reputation”; we present to the community by describing ourselves like we are. Concept strictly related to self-disclosure.

Behind the definition of a specific social media there are functional blocks (focus on which the social media is born), such as: presence, sharing, identity, relationships, conversation, groups. Every social media addresses these blocks based on the purpose of the social media (Linkedin with focus on identity, FB and Instagram on relationships, Tripadvisor on reputation, Youtube on sharing…).

The content generated on social media is called UGC (User-generated content), with both implicit incentives (mainly related to psychology, not to gain something, such as to improve relationtships, to be useful in a community, to achieve status with no personal gains related to this) or explicit incentives (to gain something, either money, reputation… for these reasons, the users may participate only because of the explicit incentive).

A virtual community is made up of a social network of individuals who interact crossing geographical and political boundaries with mutual interests. A social network is a social structure formed by social actors (either individuals or organizations) and the links that relate each user to each other. The links can be formed differently based on the social media we are considering (hashtags, friendships, likes, shares, retweets, comments, posts…). The study of these structures uses SNA (Social Network Analysis) to identify patterns (both local and global), identify influential entities and examine network dynamics.

First creation of a social media: 1971, by Ray Tomlinson, to transfer messages from one node (pc of US universities) to another; in 1973 Bulletin Board Systems are developed; in 1988 Internet Relay Chat is born; in 1990, the WWW is born; in 1997 the SixDegrees theory is developed; Myspace is created in 2003, Facebook in 2004, Twitter in 2006.

There are different types of social media: blogs (websites containing more posts about a topic), microblogging (constant publication of small contents like messages, images, videos, audio), news sides (digital versions of paper journals), forums (set of discussions in an IT platform), social networking sites (FB, Linkedin), virtual game worlds (World of Warcraft), collaborative projects (Wikipedia), content communities (Instagram, Tik Tok, Youtube, Snapchat). There are different types of data on social media: articles, posts, tweets, threads, reviews, images, videos…

Other social media characteristics, we have to provide: accessibility (easy and usually free access), global audience (so the message can be amplified), measurability (every data online can be measured), permanence (data stay for a long time), speed (it is possible to access data in real time), usability (everyone can publish and retrieve information).

Centralized social media (FB, Twitter, Instagram…): they grant free services to users and in exchange they use data shared/published by the users in any possible way. The issues related are privacy concerns (as users you need to trust the platform, and maybe “gain” something, in term of money, reputation…), the need of high scalability (for the potential huge number of users, so huge amount of data, difficult for a centralized architecture), the availability of data (in case of server shutdown/down time, data may not be accessible) and lack of interoperability between different platforms (users to share the same data needs on different platforms need to upload it separately, so APIs needs to be applied on different social media; unless centrally they are connected, like Instagram-Facebook).

The DOSN (decentralized online social network) is an online social network implemented on distributed platforms. No single service provider but a set of nodes cooperating to guarantee the functionalities offered usually by a centralized OSN. Benefits in terms of privacy (no central entity having control and storage on all users data), but problem about availability of data, security... They use the peer-to-peer architecture (every node as either a server or a client on the net), with problems related (not all nodes have the same power, security…).

Opportunistic mobile social networks are a form of mobile networks that exploit human social characteristics in common (interest, daily routines…). For example a network to share data on a university course. They don’t use the peer-to-peer architecture.

A blockchain is a type of Distributed Ledgeer Technology (DLT) consisting of growing list of records/data (blocks) securely linked together using cryptography; it reminds Peer-to-Peer architecture, but guarantee more security (so it is used for example for banks applications), but it can’t be retroactively modified (blocks are permanent and unalterable).

The last attempt to build distributed architectures overcoming some problems leads to Blockchain Online Social Media (BOSM), developed to decentralized control on social data but also introducing a rewarding system. With BOSM we can have content management without a central authority, we can have more security. Steemit is a BOSM, founded on the Steem blockchain: the social community creates and curates content in exchange for 50% of Steem Power and 50% of Steem Dollars.

Web Analytics: collect data from web pages in order to understand and optimize Web usage. Social Media Analytics: is monitoring, analyzing, measuring and interpreting digital interactions and relationships of people, topics, ideas and content. It includes sentiment analysis, natural-language processing and social networking analysis (influencer identification, profiling and scoring), and advanced techniques such as text analysis, predictive modeling and recommendations, and automated identification and classification of subject/topic, people or content.

Social Media Analysis (on data) and Social Content Analysis (on content, so text mining and natural language processing). Main social analytics tools: Facebook Insights, Twitter Analytics, Instagram Insights… They are usually represented as dashboards, usually related to frequency counts. But we can also use other instruments, such as R/Python libraries, Gephi, and tools just for visualization (Neo4J, Tableau…).

Network: set of interconnected objects (entities), of different types. Technological networks (Internet, gas, water networks, telephone network): tech infrastructures used to connect nodes to allow distribution of goods. Information networks (the WWW, email networks…): man-made networks made to share information. Biological network (biochemical, neural networks): network that represents interactions between biological elements. Social Network: networks that connect people or group of people with social interactions (like the friendship, the follow…).

With social media we can build networks, so we can use the network theory to study these networks (network theory). Network theory as part of graph theory: a network is defined by vertices (nodes) and interconnected with links (edges), which can have attributes. SNA (Social Network Analysis) is the process of investigating social structures through the use of network and graph theory. Different graph representations: algebraic, matrix, graphical… The sociogram is the original tool, made by Jacob Moreno (1889-1974) used in the context of sociometry.

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Descrizione generata automaticamenteImmagine che contiene testo

Descrizione generata automaticamenteGraph Theory was introduced by Eulero in 1700; it was first used to solve a problem of bridges (cross all the bridges in one go, with no repetition of a bridge) in the city of Konigsberg. A graph is a pair G=(V,E) of sets (where E includes V2); the elements of V are vertices, the elements of E are edges.

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Descrizione generata automaticamenteIt is usually represented in a graphical way such as that nodes are point linked by lines, which are edges. The order of the graph is the number of vertices (cardinality of vertex set). The size of the graph is the number of edges (cardinality of edge set).

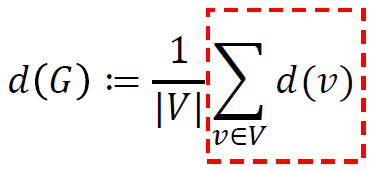
A graph is directed if all the edges have orientation (like the follow on instagram/twitter…); it is undirected if all the edges don’t have directions (like the friendship in Facebook).

With undirected graphs: the edge between two vertices is called **incident edge**; vertices linked with an edge are called **adjacent nodes**; two vertices linked by one edge are called **neighbor** to each other (a neighbor of b); two edges are **adiacent** if they have a common vertex; the **neighbourhood** (N(V1)=… are the neighbors of V1)of a node is the set of vertices adjacent to the vertex; the **star** of a vertex is the set of edges incident in the vertex.

With directed graphs (like web pages, follow…): the **outgoing edge** is ad edge from a vertex; the **ingoing edge** is ad edge to a vertex; a vertex can be **direct** **predecessor** or **direct successor**, if it comes from or to a vertex; E+(a) is a **set of outgoing edges** from the vertex a; E-(a) is a **set of ingoing edges** to the vertex a; a vertex with only incoming edges is called **sink vertex** (pozzo); a vertex with only outgoing edges is called **source vertex** (sorgente).

A loop is an is an edge whose extreme vertices are the same vertex; **multiple edges** (*archimultipli*) are (different) edges with the same pair of extreme vertices; if a graph has no loops and no multiple edges, it is called a **simple graph** (*grafo semplice*); if not, it is called a **multigraph** (*multigrafo*). We can transform multigraph in simple graph (multiple edges in a simple weighted edge).

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Descrizione generata automaticamenteIn an undirected graph, the **degree of a vertex** (node) is the number of edges incident to a node (the same concept of number of neighbors of a vertex). Each loop is counted twice. The **minimum degree** of a graph is the minimum number of all the degrees in the graph; The **maximum degree** of a graph is the maximum number of all the degrees in the graph. The average degree of a graph is the mean of degrees (sum of degrees divided by the number of vertices) (always a value between the minimum degree and the maximum degree).

**Handshaking lemma**: if the graph is constituted by m edges, the sum of all the degrees is equal to 2 times the number of edges (m) (each edge is incident at exactly 2 distinct vertices, and loop are already counted twice). If all vertices of the graph have the same k degree, they are called **k-regular**. Graphs made up of only isolated vertices are called **null graphs**. A graph where all the vertices are linked to the others are called **complete graphs**.

In directed graphs, the **in-degree** of a vertex is the number of edges arriving at the vertex; the **out-degree** of a vertex is the number of edges coming from the vertex; the **degree** of a vertex is the number of edges arriving and coming at/from the vertex (sum of in-degree and out-degree). A **subgraph** is a graph completely included in a graph; it is possible to form subgraphs of a graph by removing some vertices and/or edges from the graph (the deleting of edges doesn’t involve the deleting of vertex, but the deleting of vertex may imply the deletion of edges) (the graph without an edge is G-e, the graph without a set of edges is G-F; the graph without a vertex is G-v, the graph without a set of vertices is G-W).

A **walk** is a finite - or infinite - alternating sequence of vertices and edges adjacents (both edges and vertices can be repeated) (on simple graphs, no loops and no multiple arcs, a walk can be indicated as a sequence of vertices). A walk is **simple** if the edges and vertices are all different, otherwise is a **not simple walk**. A **trail** is a walk with all edges distinct (but vertices can be repeated), a **path** is a walk with all vertices distinct (but edges can be repeated). A **closed walk** is a walk with extreme vertices that concide. A simple and closed walks is called (**simple**) **cycle**. A **circuit** is a closed walk that allow repetition of vertices but not of edges.

The **length** of a walk is the number of edges crossed; the **distance** between two nodes is the length of the shortest path from one node to the other. The **eccentricity** of a vertex is the max distance of the vertex from any other vertex. The **radius** of the graph is the minimum eccentricity in the graph, the **diameter** of the graph is the maximum eccentricity of the graph.

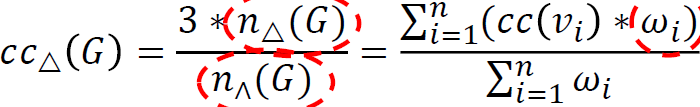
A graph is said to be **connected** when there is a path between each pair of vertices; in a connected graph, there are no unreachable vertices (a graph with only one vertex is connected). **Connectivity** is one of the basic concepts of graph theory: it is indicated by con 𝜅(𝐺) and measures the minimum number of elements (vertices or edges) that must be removed to disconnect the graph. An **articulation point** is a vertex whose removal disconnects a component of the graph. A **bridge** is an edge whose removal disconnects a component of the graph. **Biconnectivity** is when you need to remove two elements to make the graph disconnected (𝜅(𝐺)=2).

A **clique** is a structure (of at least 3 nodes) made up of a set of vertices totally connected in a graph (no single vertices, and vertex pairs are connected by an edge). The maximum clique is the largest clique in a graph. The maximal clique is a clique that can’t be extended by adding a new adjacent vertex.

# Lez 4 (boh)

Boh

# Lez 5

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Descrizione generata automaticamenteThe **clustering** (or aggregation) **coefficient** is the measure of how close is a group to being a clique (the degree to which the nodes of a graph tend to be connected to each other). There are some ways to calculate the clustering coefficient:  
- **local clustering coefficient**: number of edges between the set of neighbors of *v* - or N(*v*) - divided by the number of potential edges between them (1° directed graph, 2° undirected graph).   
- **average clustering coefficient**: the average (dividing it by the number of nodes of the graph) of the clustering coefficients for each single node of the graph  
- **global clustering coefficient**: is calculated as the number of closed triples (triangles) divided by the total number of triples in the graph.

Global clustering coefficient is related to the concept of **triples** (triads) of vertices, like open triples (3 nodes connected by 2 edges) and closed triples (3 nodes connected by 3 edges); a triple can be centered on a node; a **triangle** are 3 triples centered on the same 3 nodes that compose them.

A **labeled graph** (directed or undirected) is a graph in which an additional information called a labelis associated with each arc (edge-labeled graph) or vertex (vertex-labeled graph). A **weighted graph** is (generally) a graph labeled on edges with non-negative numbers called weights. Given a path, the **total weight** of the path is (generally) the sum of the weights on the edges in the path (like maps with km length).

A tree is a graph with some particular characteristics. An **undirected tree** is an undirected, connected, and acyclic graph in which a node is designated as the root. A **directed tree** is a directed graph that is empty or has a rootnode such that there are no arcs entering the root, each non-root node has exactly one incoming edge and for each non-root node there’s a path going from the root to the node itself.

Some concept are: **depth** of a node (the length of the path from the root to the node, i.e., number of edges crossed); **level** (the set of nodes at the same depth); **tree height** (maximum depth reached by the leaves). Like the HTML tree, or a website structure tree, or a social media tree.

Graphs may be complex for computer, in reality machines treat graphs in a way different than the graphical one: some data structures used for graph representation are adjacency matrix (an *nxn*, with n number of vertices, matrix with number of edges between each couple of vertices; with simple graph it has only 0 and 1 values; diagonal = 0), incidence matrix (a *nxm* matrix, with *n* number of vertices and *m* number of edges, with value of 1 if the edge enters the vertex, of -1 if the edge leaves the vertex or 0 otherwise) or adjacency list (array of *n* lists, with n number of vertices, that states the neighbors of each vertex).

# Lez 6

**Complex network**: complex (as “intertwined together”) system. The system as a hole is different from the sum of the distinct parts; as a consequence, it can’t be deducted by analysis, but from the interactions between the elements that compose it: these interactions give birth to emerging behaviors (collective spontaneous phenomena). To understand these behaviors we need to study the topology of the network.

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Descrizione generata automaticamenteImmagine che contiene testo, orologio

Descrizione generata automaticamenteRegular networks** are usually mathematics network (with entropy close to 0), where each node is connected to a fixed number of nodes; random networks are halfway between graph theory and probability theory. Examples of regular networks are:  
- **linear networks**: linear sequence L of connected vertices.   
- **ring networks**: linear sequence A of connected vertices, with last elements connected to first, in a ring shape (2 regular graph).   
- **star networks**: a tree S with a single vertex of maximum degree.

**Random networks** (or ER graphs, from the name of its inventor Erdos and Renyi in 1959). Random networks have pairs of nodes randomly connected by a given number of connections; two nodes are connected by a certain probability *p*. All nodes have approximately the same number of neighbors.

Complex networks (like online social networks) have different characteristics from both regular and random networks: they can be made of millions of nodes communicating with each other; mathematical methods are used to extract information for objective and synthetic purposes.

The “first order” area are contacts directed with an individual/node (this is the ego-centric network, and bring to ego-centric analysis: focused on the network surrounding of a specific node), “second order” and so on are linked via one or more links to the starting individual/node (these are called the social-centric networks, and bring to socio-centric analysis: focused on the study of complete networks).

Several phenomena are related to the theory of complex networks:  
- small-world (6 degrees of separations, Milgram experiment, experiment on exchange of emails, Erdos number, Kevin Bacon and the small-world of Hollywood)  
- clustering (communities of users almost all in a relation to each other)  
- strength of weak ties (people with less “affects” ties, but related with an interest, such as job, study… the strength of these ties can also be measured, with instruments like shortcut bridges or neighborhood overlap, or also social media instruments like interactions between users or following relationships)  
- scale invariance (scale-free networks, in the meaning that the number of relationships grow as a negative exponential type, therefore invariant under changes of scale; there are popular nodes, called hubs, and new elements who enters a network may connect more easily to some of them in respect to the others)

# Lez 7

3 main families of metrics:  
- **connection metrics**: entities connected with each other  
- **distribution metrics**: how information flow within social network  
- **segmentation metrics**: ways of “clustering” the components of social network

**Connection metrics:  
- Homophily**: the tendency for actors to form ties with similar actors (similar by gender, age, ethnicity, occupation, academic performance, status, values, beliefs…); opposite of homophily is heterophily; social medias facilitate homophilic relationships (because of personalization, filtering algorithms), which gives value to people on social medias improving the experience on them; negative aspects can be the develop of more closed communities, and the spread of filter bubbles, where only people with the same ideas interact with each other, in so-called echo chambers (more connections within a community than between different communities).   
- **Multiplexity**: the number of relationship levels contained in a link (level 2 for two friends and job collegues).  
- **Mutuality**/**reciprocity**: the extent to which two actors mutually exchange friendship or other interaction.   
- **Network closure**: it measures the completeness of relational triads (ties between A and B, and B and C, usually means strong or weak ties between A and C); synthetized by the theory of cognitive balance: propensity of two individuals to try the same thing towards a common entity; used for clustering coefficient and transitivity; both in trust networks and social networks.  
- **Proximity/Propinquity**: the tendency for actors to have more links with others who are geographically close; it uses geolocation information, or info provided directly by the users.

**Distribution metrics**:  
- **Bridges**: identification of individuals whose ties (bridges) fill a structural hole, providing the only link between two individuals or clusters.  
- **Density**: the percentage of effective links in a network out of the total possible number (n° real edges/n° potential edges; more paths, more dense).   
- **Distance**: the minimum number of ties necessary to connect two particular actors (Stanley Milgram's experiment, the idea of ​​the "six degrees of separation", the Erdos number, the Bacon number).  
- **Structural holes**: absence of links between two parts of a network.  
- **Strength of the tie**: linear combination of time, or emotional intensity, intimacy, reciprocity, etc.  
- **Centrality**: to quantify the "importance" or "influence" (in a variety of senses) of a particular node (or group of nodes) within a network; we can calculate the degree of centrality, which is the number of edges incident to a node (it can be in-degree or out-degree if it’s a direct graph); the heard behavior occurs when individuals observe the actions of all (or most) other individuals and act in a form aligned with them; we can also calculate the normalized degree of centrality; other centrality metrics are the closeness centrality (length of shortest paths from a vertex), the betweenness centrality (number of shortest paths a vertex is part of) and the delta centrality (related to the “performance” of the network to the removal of a certain element; it can also be related to the concept of efficiency, as the inverse of the distance of two nodes, the more it grows the worse the performance is) (with normalized versions for closeness and betweenness centralities).

**Segmentation metrics**:   
- **Counting of**:  
• **Cliques**, if each individual is directly related to each other individual;  
• "**Social** **circles**", groups of individuals less closely linked than in a clique.  
- **Clustering** (or aggregation) **coefficient**.  
- **Cohesion**: degree to which actors are directly connected to each other by cohesive bonds (minimum number of actors or ties of a social network that must be removed to disconnect the group; or also called connectivity).

**Neo4j Graph Platform** supports transactional processing and analytical processing of graph data. It has algorithms like: **Shortest Path Algorithms, Centrality Algorithms** (degree centrality, closeness centrality, betweenness centrality, page rank), **Community Detection Algorithms** (clustering coefficients, strongly connected components, label propagation, modularity).

# Community detection

**Community**: subset of nodes with strong, direct, intense, frequent or positive ties; nodes that interact (with friendships, likes, shares, retweets…) with each other frequently; people related with each other in different aspects (age, sex, religion, politics, interest, relationships…). A property of some networks, where, during their evolution and growth in time, a great majority of new edges are to nodes with an already high degree; the degree of these nodes thus increases disproportionately, compared to most other nodes in the network.

**Preferential attachment**: strong relationships, in a network with few very highly connected nodes and many nodes with a low degree (these are said to have a long-tailed degree distribution). Some reasons for preferential attachment: popularity (the will to be associated with popular people/ideas/items), quality (higher quality nodes may attract more attention and faster), mixed model (among nodes with similar interests, only some are going to become more popular, not based on the quality of content). There may be more or less dense communities, overlapping or disjoint communities…

Identifying network communities allows us to:  
- discover functional related objects (and interactions between nodes, like the phenomenon of polarization);  
- study interactions between groups (some individual ideas may be different from the general idea of the community);  
- infer missing node values (for example, the unknown age of someone may be similar to the mean of the age of his links);  
- predict unobserved connections (predict future links, like for friendship recommendations);

**Clustering**: data often not linked (put in matrix rows), but clustering works on distance of nodes and on similarity matrix; it may use k-means, which means that we consider only the ego-centric network. **Community detection**: data linked (like a graph), networks data tends to be discrete, leading to algorithms using graph properties directly.

4 categories of community detection methods (about taxonomy):  
- **node-centric community**: each node in a group has certain properties; nodes have some properties: complete mutuality (with cliques, we either want the maximum clique or all maximal cliques; for this we can use the brute-force method, not practical for large networks; pruning, cutting nodes with few links, can help), reachability of members, nodal degrees.   
- **group-centric community**: consider connections within a group as a whole, the group has to satisfy certain properties without considering node-level;  
- **network-centric community**: partition the whole community into several disjoint sets;  
- **hierarchy-centric community**: build a hierarchical structure of communities.